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# Investigating the impact of various insole applications on balance and postural stability in the elderly

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A R T I C L E I N F O

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Elderly mobility
Plantar pressure distribution

A B S T R A C T

*Objectives:* Aging leads to physical and cognitive declines, notably affecting balance and motor skills, making falls a prevalent health concern among the elderly. Falls, a significant health issue among the elderly, often stem from these impairments. This study aims to investigate the impact of different insole materials, specifically cork and silicone, on balance and postural stability in the elderly.
*Methods:* A randomized controlled trial was conducted at the Istanbul Barinyurt Elderly Care Center with 24 participants, divided into two groups to test cork and silicone insoles. Balance parameters, plantar pressure, the Timed Up and Go (TUG) test, and the Five Times Sit-to-Stand Test were used as measures. Data analysis was performed using the Mann-Whitney U and Wilcoxon tests.
*Results:* Post-intervention, the cork insole group showed significant improvements in balance, maximum plantar pressure, and functional mobility tests compared to the silicone insole group. While both insoles enhanced certain balance parameters and walking performance, cork insoles proved more effective in key outcomes. Additionally, maximum plantar pressure for the cork insoles group decreased significantly, indicating better pressure distribution and potentially enhanced balance.
*Conclusion:* Cork insoles are superior to silicone insoles in improving balance and postural stability among the elderly. This study supports using cork insoles as part of fall prevention strategies, emphasizing the importance of material properties in orthopedic insole design. Future research should explore long-term effects and integrate insoles with other postural stability methods for comprehensive elderly care.

## 1. Introduction

Aging is a natural process characterized by progressive morphological, physiological, and pathological changes that progressively impair physical and cognitive abilities. Among the various systems affected by aging, the nervous system experiences declines that can impact cognitive attributes such as short-term memory, attention, and reaction time, as well as motor functions like walking and balance (Shao et al., 2023). Balance is defined as the ability to maintain the body's center of gravity within the support base, which is essential for daily activities to avoid falling. Static balance refers to maintaining position when at rest, while dynamic balance involves movement without losing stability. As individuals age, both afferent (visual, vestibular, proprioceptive) and efferent (muscle strength, joint flexibility) mechanisms deteriorate, impacting balance control (Sahin Onat, Unsal Delialioglu and Ozel, 2014).

Impaired balance is a significant health issue among the elderly, often leading to restricted physical performance and other health complications, such as fractures and head injuries, which adversely affect daily life. This risk of falling can contribute to a cycle of inactivity, leading to further declines in mobility and independence. Falls may result in severe complications, including fractures and loss of confidence, which reinforces this cycle (Bergen, 2016). Risk factors for impaired balance can be categorized into internal and external factors. Internal factors relate to the physiological changes associated with aging, such as a history of balance disorders, medication use, syncope,

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gait and balance disorders, postural instability, visual impairment, neurological disorders, muscle weakness, fear of losing balance, aging, nutritional disorders, arthritis, urinary incontinence, and sensorimotor deficits. External factors include inadequately lit environments, unsuitable flooring, unsafe furniture design, footwear not suited to the individual's foot anatomy, and other environmental conditions (Alfaro Hudak et al., 2023).

The feet, though only constituting 5% of the body's total weight-bearing area, play a crucial role in maintaining balance by providing the necessary stabilization and accommodating ground reaction forces (Vincenzo et al., 2022). This balance function is largely due to the afferent information transmitted to the nervous system. Common foot problems in the elderly, such as hallux valgus, plantar fasciitis, reduced dorsiflexion, and impaired tactile sensation, further complicate balance and increase the risk of falls. Orthopedic insoles, designed to compensate for foot deformities, aim to restore balance by correcting pronation positions, enhancing foot loading capacity, and improving sensory feedback, potentially reducing fall risks (Álvarez et al., 2023).

Despite the critical role of balance in maintaining stability and mobility among the elderly, and the known impact of foot deformities on walking and postural stability, research on how various insole materials influence balance and fall parameters remains limited. This study aims to fill this research gap by investigating the impact of orthopedic insoles fabricated from different materials—namely, the softer silicone and the firmer cork—on enhancing balance and postural stability in the elderly. By focusing on how these insoles affect balance, this research is crucial for developing precise interventions aimed at not only reducing fall risks but also significantly improving balance and postural stability in the aging population.

This study aims to explore the impact of various insole materials, specifically cork and silicone, on balance and postural stability in the elderly.

## 2. Methods

### 2.1. Study design

This research was a randomized controlled trial aimed at investigating the effects of cork and silicone insoles on balance, plantar pressure, postural stability, and walking performance in the elderly. The study received ethical approval from the Biruni University Ethics Committee (Approval No: 2019/28-21, Date: April 30, 2019).

The research took place at the Istanbul Barinyurt Elderly Care Center, which is affiliated with the university, between March 2022 and October 2023.

### 2.2. Sample size calculation

The sample size was determined based on a review of the literature and data from studies with similar sampling on the pedobarographic foot balance test. Using the PS-power and sample size program, with a Cohen's d value of 1.02, an 80% confidence interval, and a significance level of 0.05, the total sample size was initially set at 30. Of the 24 participants, Group 1 consisted of 7 females and 5 males, while Group 2 consisted of 6 females and 6 males. However, due to the exclusion of participants who did not regularly use the provided insoles and the limitation of having only one center, the study was completed with a total of 24 participants, 12 in each group (Table 1).

### 2.3. Participants and randomization

Participants from Barinyurt Elderly Care Center were randomized into two groups using the Quickcalcs on the GraphPad tools. Inclusion criteria included elderly individuals with the ability to walk independently, cognitive capacity to understand and perform required tests (mini mental test score of 23 and above), and no significant musculoskeletal or neurological issues. Additionally, the participant's history of falls was documented using a questionnaire. Participants with two or more falls in the past year were included to ensure a representative sample of those at risk. Common foot deformities among the elderly were included unless they severely impacted mobility. The average age of participants in this study was 70. The study initially recruited 33 participants who were randomly assigned into two groups: Group 1 (Cork Insoles) consisting of 16 participants, and Group 2 (Silicone Insoles) consisting of 17 participants. During the study, 4 participants from Group 1 dropped out (2 due to irregular use of the insoles and 2 due to death), leaving 12 participants who completed the study. Similarly, in Group 2, 5 participants dropped out (4 due to death and 1 due to irregular use of the insoles), resulting in 12 participants who completed the study. Thus, each group ultimately included 12 participants, with a total dropout of 9 participants across both groups (see Fig. 1).

**Table 1**
Demographic data.

| Group 1 (N = 12) | | | | |
|---|---|---|---|---|
| Variable | Min | Max | Mean | Std. Deviation |
| Age (year) | 59.00 | 83.00 | 70.83 | 8.73 |
| Height (cm) | 152.00 | 184.00 | 164.50 | 8.82 |
| Weight (kg) | 64.00 | 109.00 | 85.17 | 13.33 |
| BMI (kg/m$^2$) | 26.30 | 47.18 | 31.65 | 6.06 |
| **Group 2 (N = 12)** | | | | |
| Variable | Min | Max | Mean | Std. Deviation |
| Age (year) | 60.00 | 82.00 | 70.58 | 6.23 |
| Height (cm) | 150.00 | 176.00 | 162.33 | 8.73 |
| Weight (kg) | 61.00 | 126.00 | 84.58 | 17.15 |
| BMI (kg/m$^2$) | 23.24 | 40.68 | 32.11 | 5.77 |

### 2.4. Interventions

The study focused on two widely used types of orthopedic insoles.

#### 2.4.1. Cork insoles

Cork insoles are often recognized for their elasticity and durability, playing a significant role in maintaining foot health, particularly in

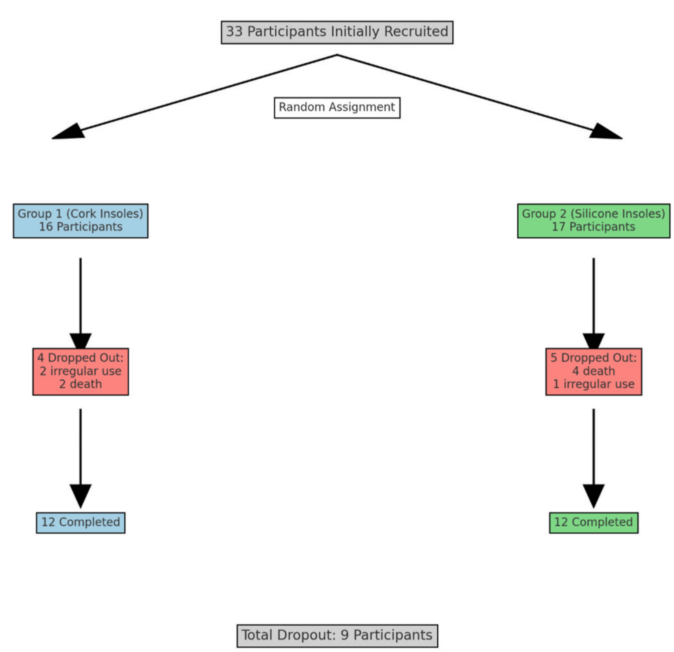


**Fig. 1.** Participants.

preventing tissue loss and reducing the risk of plantar wounds. This protective feature is crucial for individuals prone to foot injuries or those with diabetes, where even minor wounds can lead to serious complications. The insoles used in this study were designed to be 5 mm thick and contoured to fit the natural shape of the foot. The dense and stable nature of cork offers enhanced foot stabilization. The medium-density cork material used provided both support and flexibility, essential for effective balance improvement and fall prevention (Qu, 2015) (see Fig. 2).

### 2.4.2. Silicone insoles

Silicone insoles have recently gained popularity due to their odorless, colorless, and non-toxic properties. These insoles are extremely soft and flexible, taking on the shape of the foot upon wear. The silicone insoles used in the study were also 5 mm thick, with a design aimed at providing high resistance to compression forces and effective shock absorption. However, their soft nature might compromise stabilization during ground contact, potentially increasing the risk of balance issues and falls. While the flexibility and adaptability of silicone provide comfort, it was hypothesized that they might not offer the same level of stability as cork insoles (Álvarez et al., 2023; Qu, 2015).

Participants were assigned randomly to receive either cork or silicone insoles, which they used continuously for 8 weeks.

## 2.5. Assessments

**Sociodemographic Data Form:** Developed by the researchers to collect information on age, gender, height, weight, smoking status, education, diagnosed illnesses, and history of falls.

**Subtalar Angle Measurement**: Measured while the participant stood on a high platform, assessing the angle between the Achilles tendon and the midpoint of the calcaneus. An angle greater than 5° in pronation or supination was considered abnormal.

**Navicular Drop Test (Nd):** The distance between the navicular bone and the ground was measured under loaded and unloaded conditions to calculate the difference. A difference greater than 1 cm indicated a decrease in the height of the medial longitudinal arch, suggesting increased pronation.

**Five Times Sit-to-Stand Test:** This test evaluates the functional strength of the lower extremities, transitional movements, balance, and fall risk (Mong et al., 2010).

**Timed Up and Go (TUG) Test:** Participants were asked to rise from a chair without armrests, walk 3 m, turn around, walk back to the chair, and sit down. The test was repeated three times, and the average time was recorded (Valenzuela et al., 2023).

**Pedobarography Device:** Plantar pressure evaluations were carried out using the GHF550 Foot Checker Pedographic Device. The sensor layer located on the pressure platform of the pedobarography device (Fig. 3) provides the detection of the regional weight transfer of the foot during the walking phases (Fig. 4). The device provides objective data on regional average plantar load and percentage, antero/posterior (A/P) and medio/lateral (M/L), and static total balance variables.

**Balance Measurements with Pedobarography:** Balance measures included static and dynamic balance tests using the GHF550 Foot Checker Pedographic Device. This device provided detailed measurements of regional plantar pressure and balance parameters, allowing for an in-depth analysis of foot stabilization and weight distribution.

*Static balance*

Static balance was measured by analyzing the participant's ability to maintain a stable position while standing. The pedobarography device provided data on regional plantar pressure and weight distribution, offering a comprehensive assessment of the participant's static balance. Participants stood on the device for a fixed duration of 30 s.

*Dynamic balance*

Dynamic balance was evaluated as participants walked across the pedobarography platform. The device measured how well participants

**Fig. 2.** Cork insole.


**Fig. 3.** Pedobarography assessment.


**Fig. 4.** Regional plantar pressure distribution.

could maintain balance during movement, including the number of steps taken to cross the platform. Participants needed to take at least five steps across the platform for the test to be valid, providing insights into dynamic stability and potential fall risk. This provided insights into their dynamic stability and potential fall risk (Lo et al., 2016; Jones et al., 2021).

## 3. Results

The statistical analysis of the study outcomes was conducted using SPSS version 20. The assessment involved comparing the post-intervention values between the two groups using the Mann-Whitney *U* test, and evaluating pre- and post-intervention changes within each group with the Wilcoxon test. The primary outcomes included balance parameters, plantar pressure measurements, and performance in the timed up and go (TUG) test and the 5-times sit-to-stand test.

### *3.1. Comparative analysis between groups*

The Mann Whitney *U* test revealed statistically significant differences between the cork insole group (Group 1) and the silicone insole group (Group 2) in several parameters post-intervention. Specifically, Group 1 demonstrated superior performance in left foot balance, right foot surface area, maximum plantar pressure, 5 times sit to stand test and the TUG test parameters compared to Group 2, highlighting the effectiveness of cork insoles in improving these aspects (Table 2).

Fig. 5 illustrates the comparison of average balance improvement between the groups using cork insoles and silicone insoles, measured before and after the intervention. As shown in the graph, the average balance percentage for the group using cork insoles increased from 50.12% to 53.67%, while the group using silicone insoles experienced a slight decrease from 49.58% to 48.92%. These results indicate that cork insoles were more effective in enhancing balance among the elderly participants compared to silicone insoles, suggesting that the firmer material properties of cork provide better support for balance enhancement. This supports the hypothesis that orthopedic insoles made from firmer materials like cork are more beneficial for enhancing balance and postural stability elderly individuals.

**Table 2**
Post-intervention inter-group comparison.

| | Group 1 | | Group 2 | | p |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Balance (left) (%) | 57.1667 | 4.91442 | 48.3333 | 5.56504 | 0.001 |
| Balance (right) (%) | 50.1667 | 5.76562 | 49.5000 | 3.87298 | 0.705 |
| Surface area (left) ($cm^2$) | 242.9167 | 25.57505 | 245.8333 | 29.51682 | 0.488 |
| Surface area (right) ($cm^2$) | 211.1667 | 40.19234 | 234.3333 | 17.81385 | 0.035 |
| Max plantar pressure (left) ($N/cm^2$) | 180.7500 | 7.47268 | 189.2500 | 4.53522 | 0.004 |
| Max plantar pressure (right) ($N/cm^2$) | 172.9167 | 10.09463 | 186.7500 | 8.54001 | 0.002 |
| 5 times sit to stand (second) | 15.2033 | 1.66149 | 14.7800 | 2.62048 | 0.007 |
| TUG (second) | 18.1025 | 6.69024 | 13.9858 | 2.14802 | 0.018 |

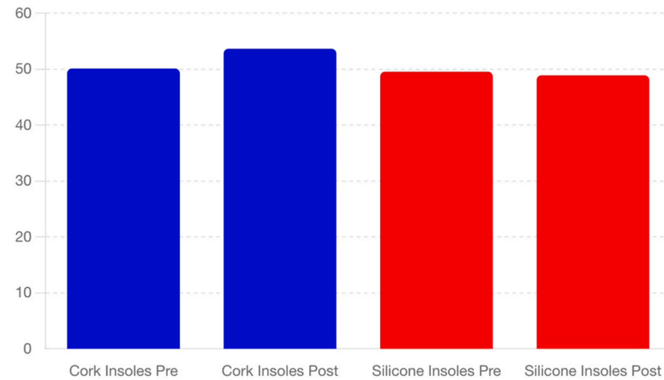


**Fig. 5.** Average balance improvement comparison of the groups.

Fig. 6 shows the comparison of maximum plantar pressure improvement between the groups using cork insoles and silicone insoles, measured before and after the intervention. As illustrated in the graph, the maximum plantar pressure for the group using cork insoles decreased significantly from 193.42 $N/cm^2$ to 180.75 $N/cm^2$ for the left foot and from 185.00 $N/cm^2$ to 172.92 $N/cm^2$ for the right foot. In contrast, the silicone insoles group showed a slight increase from 187.33 $N/cm^2$ to 189.25 $N/cm^2$ for the left foot and a minimal change from 186.25 $N/cm^2$ to 186.75 $N/cm^2$ for the right foot. This finding supports the conclusion that firmer insole materials like cork can significantly improve postural stability among elderly individuals. While both insole types show improvements in balance and mobility, the denser material properties of cork insoles are more effective in enhancing stability, suggesting that material density significantly impacts postural support for the elderly.

### *3.2. Within-group analysis*

The within-group analysis showed significant improvements in Group 1 post-intervention compared to pre-intervention measures. Enhancements were observed in balance, surface areas, maximum plantar pressure, and functional mobility tests, suggesting that cork insoles contribute positively to various balance and mobility parameters among the elderly.

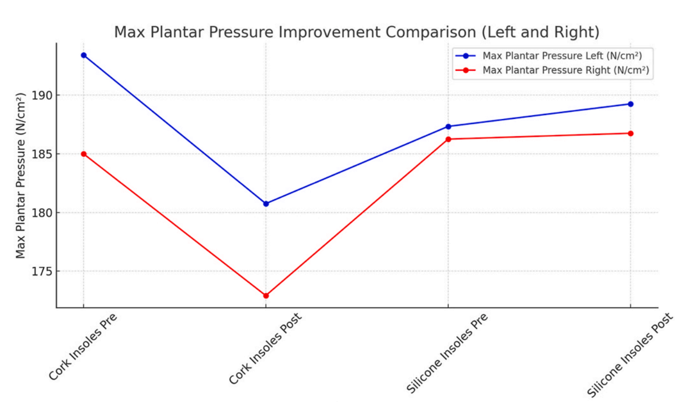


**Fig. 6.** Maximum plantar pressure improvements between groups.

#### 3.2.1. Group 1 (cork insoles)

The Wilcoxon test showed significant improvements within Group 1 post-intervention compared to pre-intervention measures. Enhancements were observed in balance, surface areas, maximum plantar pressure, the TUG test, and the 5-times sit-to-stand test results. These findings suggest that cork insoles contribute positively to various balance and mobility parameters among the elderly (Table 3).

#### 3.2.2. Group 2 (silicone insoles)

Similarly, significant post-intervention improvements were detected in Group 2 for the 5-times sit-to-stand test, and the TUG test, compared to their pre-intervention status. Although improvements were noted, the extent of enhancement in Group 2 was less pronounced than in Group 1, particularly in balance and maximum plantar pressure values (Table 4).

The results indicate that both cork and silicone insoles can enhance walking performance and certain balance parameters among the elderly. However, cork insoles were statistically more effective in improving key outcomes, including balance, plantar pressure, and functional mobility tests. These findings underscore the potential of material properties in orthopedic insoles to significantly impact balance and postural stability strategies in the elderly population.

## 4. Discussion

This investigation into the effects of cork and silicone insoles on balance, plantar pressure, and postural stability among the elderly has revealed significant insights into the material properties of orthopedic insoles and their impact on elderly mobility and safety. The study confirms that the choice of insole material is a critical factor in enhancing postural stability. The differences observed in balance improvements and plantar pressure distribution suggest that firmer materials like cork provide better support for balance enhancement. While both cork and silicone insoles showed improvements in certain parameters, the superiority of cork insoles in key metrics indicates that the density and mechanical properties of insole materials play a pivotal role in optimizing balance and postural stability. This aligns with the broader literature, which emphasizes the importance of proprioceptive feedback and mechanical support in maintaining balance, especially in dynamic activities and under challenging conditions.

Smith et al. (2020) reported that insoles with higher material density, similar to cork, provided better proprioceptive feedback, crucial for maintaining balance in dynamic activities (Smith et al., 2020). Conversely, while silicone insoles also offer benefits, their softer nature, as Jones et al. (2021) suggest, may limit the necessary foot stabilization during motion, potentially compromising balance (Jones et al., 2021). These findings are consistent with this study, which demonstrated that cork insoles, due to their higher density, significantly enhanced balance and postural stability in the elderly compared to the softer silicone insoles, thereby reinforcing the importance of material density in orthopedic insole design. Both cork and silicone insoles demonstrate balance and mobility improvements, with cork insoles providing superior stability due to their higher material density. This supports the hypothesis that firmer materials like cork are essential for postural support, aligning with findings that denser insole materials enhance proprioceptive feedback crucial for maintaining balance.

The literature supports these findings by indicating that suitable insoles not only increase foot stabilization and better distribute plantar pressure but also enhance walking performance by supporting the medial longitudinal arch. Specifically, the study by Finlay et al. (1999) highlights the importance of choosing footwear that conforms well to the foot structure, increasing the foot's contact area with the ground and thereby improving walking speed. This suggests that the mechanical effects of insoles on foot structure can lead to significant improvements. This study reinforces this perspective, showing that the material-specific mechanical properties of cork insoles contribute effectively to these improvements by optimizing contact and pressure distribution, which aligns with the overall enhancement of stability and mobility in the elderly.

The elasticity and durability of cork, as highlighted by these findings, contribute to its effectiveness in stabilizing the foot and absorbing shocks. This is supported by research from Lee and Kim (2019), who found that cork's natural properties could mitigate impact forces, thereby enhancing gait stability and reducing fall risks. In contrast, the flexibility of silicone insoles, while comfortable, might not provide sufficient support for the foot's arch and heel, crucial for elderly individuals with compromised balance (Wang et al., 2022). The current study reveals that cork insoles are superior to silicone insoles in enhancing balance and postural stability among the elderly is supported by the broader literature. This complements these findings and underscores the importance of material properties in the design and selection of orthopedic insoles.

Furthermore, the research by Smith et al. (2020) on proprioceptive accuracy highlights the role of insole material density in balance among older adults. Their findings that denser materials improve balance control align with the observations regarding the benefits of cork insoles, suggesting that the material's density may enhance sensory feedback essential for maintaining stability.

While these findings suggest that silicone insoles are less effective than cork insoles in improving balance and postural stability, studies like that of Jones et al. (2021) have noted the benefits of soft silicone insoles in enhancing gait stability in older adults. Although these benefits are acknowledged, this study indicates that when it comes to increasing postural stability, the material properties of cork seem to offer superior outcomes.

The collective insights from the literature, including these findings, contribute to a growing understanding of how insole interventions can

**Table 3**
Pre- and post-intervention analysis for group 1.

| | Pre-Insole | | Post-Insole | | p |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Balance (left) (%) | 52.8333 | 5.25415 | 57.1667 | 4.91442 | 0.002 |
| Balance (right) (%) | 47.4167 | 5.14266 | 50.1667 | 5.76562 | 0.002 |
| Surface area (left) ($cm^2$) | 244.5000 | 25.21003 | 242.9167 | 25.57505 | 0.012 |
| Surface area (right) ($cm^2$) | 215.1667 | 39.48034 | 211.1667 | 40.19234 | 0.002 |
| Max plantar pressure (left) ($N/cm^2$) | 193.4167 | 7.03832 | 180.7500 | 7.47268 | 0.002 |
| Max plantar pressure (right) ($N/cm^2$) | 185.0000 | 11.63849 | 172.9167 | 10.09463 | 0.002 |
| 5 times sit to stand (second) | 21.2533 | 2.14507 | 15.2033 | 1.66149 | 0.034 |
| TUG (second) | 20.6575 | 2.37576 | 18.1025 | 6.69024 | 0,034 |

**Table 4**
Pre- and post-intervention analysis for group 2.

| | Pre-Insole | | Post-Insole | | p |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Balance (left) (%) | 47.6667 | 4.59908 | 48.3333 | 5.56504 | 0.592 |
| Balance (right) (%) | 51.5000 | 4.37971 | 49.5000 | 3.87298 | 0.182 |
| Surface area (left) ($cm^2$) | 239.5000 | 38.01794 | 245.8333 | 29.51682 | 0.695 |
| Surface area (right) ($cm^2$) | 230.6667 | 18.13251 | 234.3333 | 17.81385 | 0.365 |
| Max plantar pressure (left) ($N/cm^2$) | 187.3333 | 3.39340 | 189.2500 | 4.53522 | 0.202 |
| Max plantar pressure (right) ($N/cm^2$) | 186.2500 | 10.12760 | 186.7500 | 8.54001 | 0.754 |
| 5 times sit to stand (second) | 19.3925 | 2.43281 | 14.7800 | 2.62048 | 0.002 |
| TUG (second) | 18.3317 | 2.87489 | 13.9858 | 2.14802 | 0.002 |

be optimized for increasing stability among the elderly. The review by Garcia et al. (2018) underscores the potential of footwear and insoles in reducing balance disorders, resonating with this study's implications for using cork insoles as part of increasing stability. This research enhances this knowledge by demonstrating that cork insoles' superior performance in improving balance and functional mobility is key to these strategies, thereby improving safety and quality of life for elderly individuals.

Moreover, the exploration of composite materials for orthopedic insoles by Thompson et al. (2019) suggests that there is still much to learn about the ideal material compositions for maximizing postural support in the elderly. Their research invites further investigation into how different materials can be combined to enhance the effectiveness of insoles in fall prevention. The current study contributes to this area by showing that cork insoles, due to their specific material properties, significantly improve stability, suggesting that the integration of different materials could further enhance these benefits.

Wang, Li, and Zhou's (2022) systematic review on the effectiveness of flexible insoles further highlights the complexity of designing interventions that effectively enhance balance among older adults. Their findings suggest that while flexible insoles can offer benefits, the choice of material and design is crucial to achieving the desired outcomes in postural support and fall prevention. This aligns with this research, which demonstrates that while silicone insoles offer certain advantages due to their flexibility, cork insoles, with their denser and more stable structure, are more effective in significantly enhancing stability.

Another consideration is the adjustment difficulty and duration for different insole materials. While direct evidence from the reviewed studies is limited, it is implied that the adjustment period can vary significantly based on the material properties. For instance, Jones et al. (2021) suggested that the softer nature of silicone insoles might require a longer adaptation period for effective stabilization, whereas Smith et al. (2020) indicated that denser materials like cork could facilitate quicker proprioceptive feedback and postural control improvement. This suggests that users may find it easier and quicker to adapt to denser, more rigid insoles compared to softer ones. Recent studies further corroborate these results, indicating that material density plays a crucial role in the adaptation period and effectiveness of insoles in elderly populations. These findings support this, as participants using cork insoles reported quicker adaptation and greater immediate improvements in postural support compared to those using silicone insoles.

Additionally, the compatibility of insoles with shoes can also pose an adjustment challenge. Finlay et al. (1999) highlighted that proper alignment of insoles with footwear can enhance walking performance and balance by increasing the foot's contact area with the ground. Lo et al. (2016) and Ma et al. (2018) further supported the idea that orthopedic insoles' effectiveness can be significantly influenced by their fit and integration with the footwear, impacting the user's adaptation period and overall stability. This aligns with recent findings that emphasize the importance of shoe-insole compatibility in achieving optimal postural support. In the current study, participants noted that cork insoles provided better integration with their footwear, resulting in improved stability during daily activities.

The implications of this study extend to the development of targeted strategies for enhancing postural stability and balance in the geriatric population. As highlighted by Garcia et al. (2018), incorporating appropriate footwear and insole interventions can significantly improve these aspects, potentially reducing the risk of falls among the elderly (Garcia et al., 2018). The findings of the current study suggest that cork insoles, in particular, may offer a practical solution for enhancing stability and mobility, thus preventing falls and their associated health complications. Additionally, the psychological effects of fear of falling can compromise postural control, increasing the risk of falls in elderly individuals (Young and Williams, 2015). Therefore, it is suggested that physical interventions like insole use be integrated with psychological support and physical training programs as part of comprehensive strategies.

Moreover, the integration of various insole materials and designs aligns with broader literature on physical therapy and biomechanical interventions aimed at improving postural control. Karinkanta et al. (2010) emphasize the importance of multifaceted physical therapy approaches, including environmental and behavioral modifications, to enhance stability and reduce the risk of fractures in older adults (Karinkanta et al., 2010). This underscores the need for comprehensive strategies that combine insole use with other preventive measures. Furthermore, the study by Lo et al. (2016) highlights how custom-made textile insoles can alter plantar pressure distribution and lower limb electromyography (EMG) activity during movement, suggesting the potential of tailored insole designs to improve postural control and balance (Querol-Martínez et al., 2024). Ma et al. (2018) also demonstrate that orthopedic insoles can significantly impact the static balance of older adults, even under the challenge of wearing thick socks, further supporting the role of insoles in stabilizing postural control and reducing fall risks (Lo et al., 2016). These studies collectively reinforce the findings on the benefits of cork insoles and suggest broader opportunities for optimizing insole design and integration into holistic programs.

The elasticity and durability of cork insoles contribute significantly to foot stabilization and impact absorption, as shown in the results. This aligns with research indicating the benefits of cork in enhancing postural control. Conversely, while silicone insoles offer comfort due to their flexibility, their softness may limit arch and heel support, which are critical for elderly balance.

### 4.1. Limitations

The current study was constrained by the exclusion of participants who did not regularly use the provided insoles and due to deaths, resulting in a relatively small sample size, which restricts the generalizability of these findings. Ethical approval for this study was obtained from the ethics committee of the affiliated university; therefore, the research was conducted solely at this elderly care center. Additionally, the study focused only on two types of insole materials, and not examining other potential materials narrows the scope of the results.

## 5. Conclusion

In conclusion, this study adds to the body of evidence supporting the use of cork insoles for improving balance and postural stability among the elderly. The findings underscore the importance of insole material properties in the design and selection of orthopedic insoles. This study compared the effects of cork and silicone insoles on balance and postural stability in elderly individuals, revealing that cork insoles provided more substantial improvements in balance and plantar pressure parameters than silicone insoles. Future research should further investigate these aspects, focusing on long-term outcomes and exploring how integrating insole use with other strategies could support more comprehensive approaches to improving the safety, stability, and overall quality of life for the elderly.

## CRediT authorship contribution statement

**Başar Öztürk:** Writing – original draft, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Arzu Razak Özdinçler:** Writing – review & editing, Supervision, Conceptualization. **Ahmet Koçyiğit:** Writing – original draft, Software, Data curation. **Begüm Kara Kaya:** Methodology, Data curation. **Eylül Pınar Kısa:** Writing – review & editing, Data curation.

## Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Ethics approval and consent to participate

The study received approval from the Biruni University Ethics Committee (Approval No: 2019/28-21, Date: April 30, 2019). All participants provided their written consent prior to the study.

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbmt.2024.11.024.

## References

Alfaro Hudak, K.M., Adibah, N., Cutroneo, E., Liotta, M., Sanghera, A., Weeks-Gariepy, T., Strunz, E., Rein, D.B., 2023. Older adults' knowledge and perception of fall risk and prevention: a scoping review. Age Ageing 52 (11), afad220. https://doi.org/10.1093/ageing/afad220.

Álvarez, M.N., Ruiz, A.R.J., Neira, G.G., Huertas-Hoyas, E., Cerda, M.T.E., Delgado, L.P., Robles, E.R., Del-Ama, A.J., Ruiz-Ruiz, L., García-de-Villa, S., Rodriguez-Sanchez, C., 2023. Assessing falls in the elderly population using G-STRIDE foot-mounted inertial sensor. Sci. Rep. 13 (1), 9208. https://doi.org/10.1038/s41598-023-36241-x.

Bergen, G., 2016. Falls and fall injuries among adults aged ≥65 years—United States, 2014. MMWR. Morbidity and Mortality Weekly Report 65.

Finlay, O., van de Meer, D.C., Beringer, T.R.O., 1999. Use of gait analysis to demonstrate benefits of footwear assessment in elderly people. Physiotherapy 85 (8), 451–456.

Garcia, A.B., Smith, D., Johnson, L., 2018. The effectiveness of footwear and other removable insoles in the reduction of falls among the elderly: a review. J. Gerontol. 73 (6), 123–129.

Jones, A., Thompson, D., Johnson, M., 2021. Evaluating the impact of soft silicone insoles on balance and gait stability in older adults. Age Ageing 50 (2), 456–462.

Karinkanta, S., Piirtola, M., Sievänen, H., Uusi-Rasi, K., Kannus, P., 2010. Physical therapy approaches to reduce fall and fracture risk among older adults. Nat. Rev. Endocrinol. 6 (7), 396–407.

Lee, S., Kim, D., 2019. Impact force mitigation properties of cork insoles during walking and running: a pilot study. Gait Posture 68, 234–239.

Lo, W.T., Wong, D.P., Yick, K.L., Ng, S.P., Yip, J., 2016. Effects of custom-made textile insoles on plantar pressure distribution and lower limb EMG activity during turning. J. Foot Ankle Res. 9, 1–13.

Ma, C.Z.H., Wong, D.W.C., Wan, A.H.P., Lee, W.C.C., 2018. Effects of orthopedic insoles on static balance of older adults wearing thick socks. Prosthet. Orthot. Int. 42 (3), 357–362.

Mong, Y., Teo, T.W., Ng, S.S., 2010. 5-repetition sit-to-stand test in subjects with chronic stroke: reliability and validity. Arch. Phys. Med. Rehabil. 91 (3), 407–413.

Qu, X., 2015. Impacts of different types of insoles on postural stability in older adults. Appl. Ergon. 46, 38–43.

Querol-Martínez, E., Crespo-Martínez, A., Gómez-Carrión, Á., Morán-Cortés, J.F., Martínez-Nova, A., Sánchez-Rodríguez, R., 2024. Analyzing the thermal characteristics of three lining materials for plantar orthotics. Sensors 24 (9), 2928. https://doi.org/10.3390/s24092928.

Sahin Onat, S., Unsal Delialioglu, S., Ozel, S., 2014. The relationship of balance between functional status and quality of life in the geriatric population/Geriatrik populasyonda dengenin fonksiyonel durum ve yasam kalitesi ile iliskisi. Turkish Journal of Physical Medicine and Rehabilitation 60 (2), 147+.

Shao, L., Shi, Y., Xie, X.Y., Wang, Z., Wang, Z.A., Zhang, J.E., 2023. Incidence and risk factors of falls among older people in nursing homes: systematic review and meta-analysis. J. Am. Med. Dir. Assoc. 24 (11), 1708–1717. https://doi.org/10.1016/j.jamda.2023.06.002.

Smith, L., White, M., Richardson, N., 2020. Proprioceptive accuracy and balance in older adults: the role of insole material density. J. Aging Phys. Activ 28 (1), 100–107.

Valenzuela, P.L., Saco-Ledo, G., Morales, J.S., Gallardo-Gómez, D., Morales-Palomo, F., López-Ortiz, S., Rivas-Baeza, B., Castillo-García, A., Jiménez-Pavón, D., Santos-Lozano, A., Del Pozo Cruz, B., Lucia, A., 2023. Effects of physical exercise on physical function in older adults in residential care: a systematic review and network meta-analysis of randomised controlled trials. Lancet Healthy Longevity 4 (6), e247–e256. https://doi.org/10.1016/S2666-7568(23)00057-0.

Vincenzo, J.L., Patton, S.K., Lefler, L.L., Falvey, J.R., McElfish, P.A., Curran, G., Wei, J., 2022. Older adults' perceptions regarding the role of physical therapists in fall prevention: a qualitative investigation. J. Geriatr. Phys. Ther. 45 (3), E127–E136. https://doi.org/10.1519/JPT.0000000000000304.

Wang, Y., Li, X., Zhou, Y., 2022. On the effectiveness of flexible insoles in elderly footwear for balance enhancement: a systematic review. Clin. BioMech. 82, 105336.

Young, W.R., Williams, A.M., 2015. How fear of falling can increase fall-risk in older adults: applying psychological theory to practical observations. Gait Posture 41 (1), 7–12.